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COMPARATIVE NEUROLOGY.

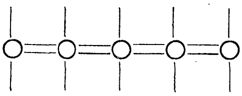
BY S. V. CLEVENGER, M.D.

[*Continued.*]

AT this stage the so-called afferent commissure alone is established, but the same law of unification of segments in the construction of an individual from its component colonial members will also confer upon it an efferent commissural system.

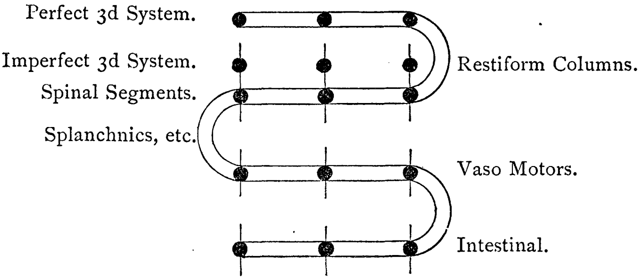
While this is intended to represent the visceral nervous system of Invertebrata, the same rule will apply in the union of vertebral ganglia segments in higher forms, beginning in such Invertebrata as possess more than one secondary system ganglia (some Arthropoda).

Ganglionary fusions occur in parasitic insects and other forms, but this is secondary and does not interfere with the general application. By omitting the afferent part of the fibers that form the commissures, the segmental union may be expressed thus, and confusion avoided:

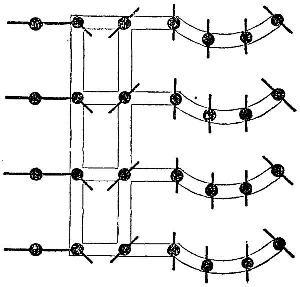


These may be schematically expressed in diagrams which show the higher ganglionic series to be commissurally connected with the lower. Each higher segment presiding over a lower system series and the commissures between forming apparently, direct projection systems.

This scheme would explain why the splanchnics have no inhibitory control over the intestines (Ludwig and Haffter), such control really pertaining to higher projections (Ott).



Each spinal ganglion segment presiding over a similar series would be thus represented:



While each and every ganglion preserves its primary projection functions, the commissures interrelate the systems and are themselves projection fibers.

The third system in this diagram is incomplete in not being commissurally connected, hence it is but a ganglionic (intervertebral) swelling upon the secondary spinal afferent nerves, and attains its complete functional character within the cranium only.

In Trigla adriatica the brain and dorsum of the cord are marked by a double chain of well-developed tubercles on the secondary nerves just as they enter the cord. These ganglionic enlargements are exact reproductions of the cerebellar and cerebral enlargements, en chatelaine. These intervertebral ganglia constitute the third system, the difference between the spinal ganglia and those above being that the latter are commissurally united to one another, and in higher Vertebrata fused longitudinally.

The vermis of the cerebellum is probably a mere commissure compounded of different segmental heights, for the transverse striations are pronounced in birds and some reptiles.

According to Owen, the cerebellum (vermis) retains its embryonic form of a simple commissural bridge or fold in the parasitic suctorial Cyclostomes and sturgeon, and in the almost finless Lepidosiren, while the cerebellum (still vermis, because centrally placed) is highly developed in the sharks. In the saw fish it even rests upon the "cerebrum."

The first well-marked posterior ganglionary mass which in higher Vertebrata becomes a portion of the cerebellum, is the vagus tubercle, placed posterior to and below the "cerebellum" of the fox shark. It might be safe to assume that subsequently this tubercle (third system ganglion) forms the flocculus or pneumogastric lobule of the cerebellum.

The Gasserian ganglion (unmistakably an intervertebral), where non-existent, must form a portion of the cerebellum.

The cerebellum then appears to be formed from fused hypertrophied intervertebral ganglia.

Stilling regarded the law of isolated conduction as inapplicable to the cerebellar lobes, owing to the very great commissural (fused) union which occurs there. Thus a coördinating function between cranial nerves on the one hand (the cerebellum acting as connected intervertebral ganglia for many cranial nerve fibers), and the general spinal system on the other, must follow in such Vertebrata as are governed mainly by cerebellar supervision, while in higher forms it is brought directly into relation with the cerebrum itself.

Above this the cephalic intervertebral ganglia developed in some animals, atrophic or rudimentary in others, appears to be the posterior and anterior tubercula bigemina, epiphisis cerebri, eminentia mammillaria, olfactory lobes, cerebrum, which latter is itself composed of several lobes or ganglia, some of which, as the anterior, are undeveloped in most Vertebrata and even in many mammals.

The posterior bigeminal lobe appears to be a third system ganglion related to special tactile sense (see Spitzka, N. Y. *Medical Record,* March 13, 1880), while the optic lobes (anterior bigeminal) are third systems for the optic nerves. The primitive optic fibers were related to the gray matter above the chiasma, and even in man retain some primary thalamic connections.

The epiphisis cerebri (pineal gland), bilobed in the fœtus and devoid of sabulous matter in forms below man, attains quite a large size in some animals (*Meleagris gallapavo,* p. 260 " Huxley's Vertebrates "). It may with the mammillary eminence indicate a sense between sight and olfaction.

The mammillary eminences can be third systems, their positions and cinereal envelope weighing nothing against the idea, for the Teliost cerebrum itself drops to a comparably defective structure and inferior position.

These eminences are very large in monotremes, marsupials and the horse. They stand related to the fornix, which in turn is connected to the olfactory lobe.

The olfactory lobe (another third system ganglion) appears to have been derived from a place lying in front of the mammillary eminences, according to Luys' sections, but Meynert is doubtless more correct in attaching the olfactory primitively to the optic thalamus.

The olfactory lobes, of more importance in some vertebrates than the cerebrum, in man became strangled, so to speak, by the preponderance of higher third systems.

(" The olfactory lobe bore such important relations to the life history of early vertebrates that we are not surprised to find the *cerebral hemispheres* developing at first as mere appendages of the olfactory lobes."—Spitzka, " Architecture and Mechanism of the Brain," p. 37.)

The lobes of the cerebrum are related to the corpus striatum, which seems to be a part of the medullary gray second system, though formed after the hypophysis cerebri had become atrophic as the end of the spinal cord.

The hypophysis ended in the sella turcica and the corpus striatum (caudate nucleus), and subsequently lenticular nucleus developed in the scale of intelligence (Meynert).

In Teliost fishes the optic lobe (third system) occupies the place of the cerebrum of mammals in point of mass development, and the inference is natural that this optic lobe contains the highest centers related to the psychic life of this division of vertebrates. The cerebrum proper being an undeveloped tubercle in front of the mammillary eminence with the infundibulum between them (Todd, p. 619, Vol. III).

In Amphioxus we have the culmination of the secondary ganglionic type with the foreshadowing, seemingly, of the tertiary, in the black pigmentary formation in the dorsal portion of the notochord. This vertebrate, so far from being anomalous, explains by its rudimentary organization what appears later in the Cyclostomi or above. Its second pair of nerves runs from the dorsal segmental nerves to the head-end ganglion, thence to the ventral segmental nerves, typifying the medulla oblongata control over lower centers, without the intervention of a cerebellar or any other third system.

The optic ganglion (secondary) of the crab *(Carcinus mœnas)* topographically precedes the antennal, from which may be inferred that the posterior bigeminal (tertiary) is related, as Spitzka claims, to the special tactile (fifth pair) sense.

The slight development of the superior ganglia in Brachiopoda is correlated with higher sensory organs, and Gegenbaur, p. 310, notices that the nerves for the arms are probably given off from the *ventral ganglia*, a condition which I suspect is more common than usually thought to be the case, due to the want of differentiation between alimentary and locomotor parts, so far at least as central innervation is concerned. " In the Mollusca the visceral ganglia are not only of importance, as forming a part of the general nervous system, but they may also fuse with the cerebral ganglia, owing to the gradual shortening of their commissures. New and primitively peripherally placed parts are thereby added on to the central organs, and it becomes a matter of doubt whether or no these ganglia, which formerly belonged to the visceral nervous system should still be regarded as belonging to it."—Gegenbaur, p. 344.

The development of the nervous system appears to have proceeded as follows:

PRIMARY.

Intestinal—Circulatory and visceral, cardiac.

SECONDARY.

Respiratory—Special tactile locomotory, auditory, optic, or optic and next auditory.

Antennal special tactile from which auditory in some; (olfactory not certain in Invertebrata, possibly in Cephalopoda. *In Vertebrata originate highest secondary and tertiary).*

The progression of faculties intermingle and a branch sense appears often to develop indifferently from one or other trunk, as while respiratory may give rise to the tactile for locomotion, and audition follows upon this, the antennal for gustatory purposes may originate the auditory, while locomotor tactile may be developed separately.

NERVOUS ORGANIZATION OF INVERTEBRATA.

1. *Protozoa.*—Not perceptibly differentiated.
2. *Cœlenterates.*—Rudimentary primary.
3. *Vermes.*
4. *Echinodermata.* } Secondary appears and becomes highly developed. Often fused with primary.
5. *Arthropoda.* } Secondary well developed. In Insecta the primary quantitatively developed. Tertiary pronounced in bee.

6. *Brachiopoda.*—Degraded secondary.

7. *Mollusca.*
Resemble Vermes.
Secondary feeble in Lamellibranchiata.
Secondary well formed in Gastropoda.

8. *Tunicata.*
Secondary well defined (extending by commissures dorsally (?) Copelata).
First appearance of extended secondary in Invertebrata.
Anterior ganglia vesicularly developed.

Gegenbaur (p. 501) justifies this view of the central nervous system of Vertebrata being homologous with the superior central ganglia of Invertebrata "in an exceedingly high state of development."

The dorsal position of the central nervous system can be well made out in Tunicata. It proceeds from ectodermal differentiation.

An anterior larger mass divides into three consecutive (secondary) lobes, produced by unequal thickening of the walls of the central tube.

The anterior mass is in connection with the origin of the visual organs in Ascidiæ, Salpæ and Copelata.

A median dorsal nerve cord appears in ascidian larvæ, which prolongation Gegenbaur, p. 396, regards as noteworthy as being the only *dorsal* prolongation in Invertebrata, and thus a medullary secondary central system appears stretching the length of the animal.

Notwithstanding the feeble development of the cerebral ganglia in Mollusca, the homology of these ganglia with the cerebral ganglia of Vermes and of Arthropoda has been clearly made out. There exist in Arthropoda and Mollusca cerebral (secondary) ganglia connected with nerves of special sense and visceral (primary) ganglia innervating, in Mollusca, the heart, branchial apparatus and generative organs, comparable to the " stomato gastric nervous system " of Arthropoda.

The ventral chain of ganglia, so obvious in Crustacea and Insecta, partakes of primary or secondary characteristics, or both, depending upon the position of the metamera and the degree of development they have undergone. With concrescence of the anterior metamera into a more or less extended cephalothorax, the anterior ganglionic masses are fused, as in Stomapoda, where a portion of this ventral chain innervates the anterior buccal and and prehensile feet, while the six smaller ganglia of the abdomen still correspond to the segments and have more apparent primary than secondary significance. In Arachnida, where nerves are given off to the enteron from both the cerebral and ventral ganglia, an appearance is presented of the vertebrate pneumogastric projection.

Recent embryological observations, as set forth by Balfour ("Comparative Embryology," Vol. 1, 1880) from monographs of Kowalevsky, Kleinenberg, Fol, Lankester and others, distinctly show that where the nervous system has been made out at all, as a rule it proceeds from epiblastic thickening and differentiation.

The First System arises from intestinal innervation, the ganglion of which affords, in Invertebrata, locomotor nervous control. The respiratory, digestive, and excretory functions, as in larva of dragon fly and fish Cobitis, being performed, not only by the same sets of nerves, but the same organs (*vide* Darwin's "Origin of Species," p. 170). We have seen locomotion to proceed as an accidental accompaniment of respiration (Branchipus), and the sub-œsophageal ganglion innervating the second pair of antennæ in Nauplius.

The vaso-motor division of the first system is added when the mesoblast appears and the vascular is differentiated. The concentration of the fibers and ganglia of this system in certain areas, as the solar plexus, renders any attempt at systematic classification of strands, etc., futile, but by studying the arrangement of the sympathetic system backward from the præ-vertebral ganglia, the warrant for the scheme I have adopted is more apparent. The præ-vertebral are united by longitudinal commissures, precisely as in the ventral chain of ganglia in Arthropoda; often as in the cervical region these ganglia coalesce to form larger nerve centers, precisely as in cephalo-thoracic formation from metamera, or as in the leech; one ganglion may in the adult represent three of the embryonic segmental ganglia.

No matter how exalted the function or position pertaining to a ganglion *in any system*, it does not lose its identity as a simple center from which afferent and efferent fibers proceed. The prævertebral chain presides directly as centers over the immediate vascular area with which it lies in contact, with its more or less obscure peripheral projections, while the commissural system binding it to the visceral plexuses lengthen and broaden out into such great fasciculi as the splanchnic and cardiac nerves.

Second System Ganglia.—By quantitative caudal development of the cerebral ganglia homologies of Invertebrata, as supra-œsophageal, optic, auditory, pedal, or tactile, commissurally connected by afferent fibers posteriorly (columns of Goll and Burdach), and by efferent fibers anteriorly (columns of Türck and anterior fundamental tract), a view is obtained of the primitive spinal cord segments ununited. Spitzka records that the planes of junction of the original segments may be still made out by the poorness in cellular elements of such areas under microscopic examination, while the centers of the spinal ganglia are determinable by their richness in these elements. Longitudinal fusion and consequent shortening of this chain forms the central tubular gray of the spinal cord.

The "medullary white" of Flechsig first appears in the columns of Burdach, in the fœtus of 25 c.m. Spitzka says it also appears in the processus cerebello ad cerebrum. This is reasonable, for the processus cerebello ad cerebrum is a continuation of the columns of Goll and Burdach, as will appear later in this description.

The second system ganglia consist of:

1. All the coalesced segments which form the spinal cord.
2. The medulla oblongata gray.
3. The gray masses in the pons Varolii.
4. The optic thalami and soft commissure.
5. The tuber cinereum.
6. The (doubtful) olfactory ganglion of Luys.
7. The caudate and lenticular nuclei of the corpora striata.

The hypophisis cerebri being the atrophied end of the cord, needs no numerical consideration.

Third System Ganglia.—Turning again to the Amphioxus, we find that the second system ganglia, or spinal cord, give off afferent and efferent nerves dorsally and ventrally, *without intervertebral ganglia, cerebellum, or anything resembling a cerebrum.* The "second pair" of nerves of the head end, instead of passing ventrally and dorsally, as do those of the lower segments, run backward or caudally; those which run from the tail to the head along the dorsum, are afferent, while those projected backward along the ventral portion of the body, are efferent.

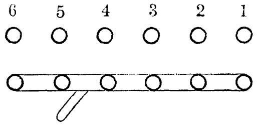
These sets of nerves resemble strikingly in many particulars, the pneumogastric nerves *and the lateral columns of the spinal cord* of higher Vertebrata. Confer ganglionic swellings upon all these afferent spinal nerves of the Amphioxus, proportioning their sizes to the nerve bundle sizes, and an appearance is presented like that which obtains in *Trigla adriatica,* a series of dorsal (intervertebral) ganglia from tail to head forming intervertebral ganglia, cerebellum, optic lobe (so-called cerebrum), and the higher series differ from the lower only in point of mass.

The crura cerebri and tegmental fibers thus become efferent and afferent nerves from the higher homologues of the central tubular gray; the corpora striata and optic thalamus, and these fibers with part of the restiform column project at different levels *from and to the spinal gray as peripheries* along the antero and postero-lateral columns of the cord. But this does not comprise *all* of the projection series from these parts for the cerebro-spinal nerves have their primary projections as well.

Morphology of the Third System Lobes.—The position of the cerebellum and its recognizable phylogenetic changes may be easily traced through the Vertebrata generally, but the lobes superior to it undergo a variety of distortions and changes of position, for the solution of which we must resort to schematic views.

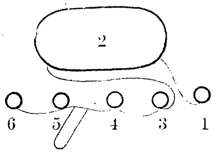
Given, a series of tubercles which shall from behind forward represent the lobes of the brain, as follows:

1. Posterior pair of tubercula quadrigemina.
2. Anterior pair of tubercula quadrigemina.
3. Epiphisis cerebri.
4. Mammillary eminence.
5. Olfactory lobe.
6. Cerebrum.

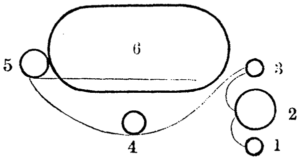


The gray secondary of each being united by commissures, the afferent and efferent. The first of these commissures it will be most convenient to follow through the developmental gyrations as apparently connecting the under surface of each lobe, but in reality connecting the secondary segments pertaining to each, as optic thalamus, tuber cinereum, olfactory ganglion and corpus striatum.

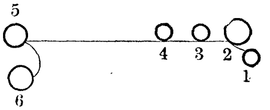
1 is connected to 2 and 3 by the upper end of the brachium conjunctivum, 3 to 4 by prolonged habenulæ, 4 to 5 by fornix, 5 to 6 by hippocampal fibers, tractus Lancisi and gyrus fornicatus (the latter principally). In the case of a fish with optic lobe (2) developed covering the other tubercles, the course of the commissures and relative mass appearance would be thus :



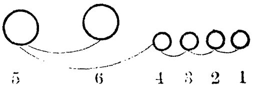
Bird, as pigeon, with cerebrum developed covering 1 to 5, the optic lobe being pressed to one side.



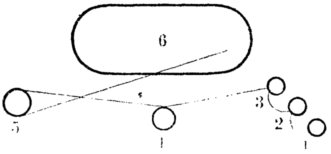
The following appears to be the arrangement of the brain of the fox shark, with lobes equally developed. I think the main mass must be the optic thalamus with the quadrigeminal bodies fused on its surface (this latter feature not represented here).



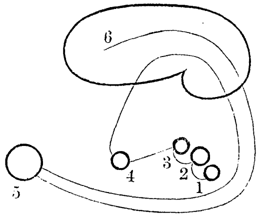
This form appears in the mammal with equally large olfactory lobe and cerebrum.



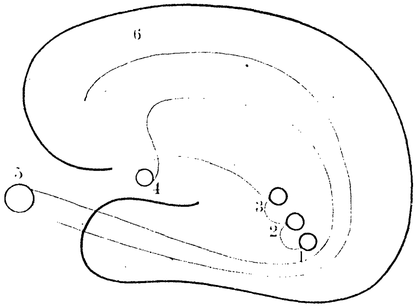
Evolution of the afferent longitudinal commissures, fissure of Sylvius and temporal lobe.—This condition is presented by an unconvoluted brain such as the beaver's, which is but faintly fissured.



An illustration of the gradual appearance of the Sylvian fissure with the hippocampal formation, is attempted below:



The last cut represents the Sylvian fissure formed as in man, with the accompanying fascicular distortions:



The growth of the frontal lobe in proportion to the intelligence of the primate individual, augments this creation of temporal. Many of the longitudinal sulci of the quadrumana fold over and under with this advancement of the occipital into temporal, and the parieto-occipital fissure on the median face of the cerebral hemisphere is doubtless created directly by this bend, and the calcarine may also owe its origin to this change. A variety of causes combine, however, in fissure formation, aside from those mentioned.

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THE BEE'S TONGUE, AND GLANDS CONNECTED WITH IT.

BY JUSTIN SPAULDING.

THE present paper is the outcome of an interest in the subject awakened by an article, by Mr. J. D. Hyatt, on the sting of the honey bee, in the *American Quarterly Microscopical Journal* for October, 1878, followed by one on the structure of the tongue by the same, July, 1879. Both bear impress of careful and painstaking interpretation of facts, and a genius in manipulation that is truly marvelous. Mr. Chamber's article, prior to Mr. Hyatt's